

**STUDY OF ADSORPTION OF DRUG AND CALCULATION OF FREUNDLICH ADSORPTION ISOTHERM**Amita Tilak^{1*}, Ravindra Nath Thakur*, Ranjana Sharma*, Minakshi Verma*, Ashish Kumar Gupta

*Department of pharmacy, G.S.V.M. Medical College, Kanpur

Department of pharmacy, V.B.S. Purvanchal University Jaunpur

ARTICLE INFO**Research Article**

Received 18 July 2016

Accepted 30 July 2016

Corresponding Author:

Ashish Kumar GuptaDepartment of pharmacy,
V.B.S. Purvanchal University, Jaunpur**ABSTRACT**

Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. Adsorption is a surface-based process while absorption involves the whole volume of the material. The term sorption encompasses both processes, while desorption is the reverse of it. Adsorption is a surface phenomenon. The aim of present study was to study the effect of adsorbent (charcoal) on the adsorption of oxalic acid. It can be concluded that C_s increases exponentially with increases in Y and $\log K$ value was 0.148 and $1/n$ was equal to 0.674.

Keywords: Solubility, oxalic acid, Charcoal, Adsorption

©WWW.IJPBA.IN, All Right Reserved.

INTRODUCTION

This process creates a film of the adsorbate on the surface of the adsorbent. This process differs from absorption, in which a fluid (the adsorbate) is dissolved by or permeates a liquid or solid (the adsorbent), respectively. Adsorption is a surface-based process while absorption involves the whole volume of the material. The term sorption encompasses both processes, while desorption is the reverse of it. Adsorption is a surface phenomenon [1-4].

Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent, or metallic) of the constituent atoms of the material are filled by other atoms in the material. However, atoms on the surface of the adsorbent are not wholly surrounded by other adsorbent atoms and therefore can attract adsorbates. The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorptions (characteristic of covalent bonding). It may also occur due to electrostatic attraction [4-6].

Adsorption is present in many natural, physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, capturing and using waste heat to provide cold water for air conditioning and other process requirements (adsorption chillers), synthetic resins, increase storage capacity of carbide-derived carbons, and water

purification. Adsorption, ion exchange, and chromatography are sorption processes in which certain adsorbates are selectively transferred from the fluid phase to the surface of insoluble, rigid particles suspended in a vessel or packed in a column. Pharmaceutical industry applications, which use adsorption as a means to prolong neurological exposure to specific drugs or parts thereof, are lesser known. The word "adsorption" was coined in 1881 by German physicist Heinrich Kayser (1853-1940) [5-9].

The Freundlich equation or Freundlich adsorption isotherm, an adsorption isotherm, is an empirical relation between the concentrations of a solute on the surface of an adsorbent to the concentration of the solute in the liquid with which it is in contact. In 1909, Herbert Freundlich gave an expression representing the isothermal variation of adsorption of a quantity of gas adsorbed by unit mass of solid adsorbent with pressure. This equation is known as Freundlich adsorption isotherm or Freundlich adsorption equation. As this relationship is entirely empirical, in the case where adsorption behavior can be properly fit by isotherms with a theoretical basis, it is usually appropriate to use such isotherms instead (see for example the Langmuir and BET adsorption theories) [6-9].

Freundlich adsorption isotherm

Example of the Freundlich isotherm [7-9], showing the amount adsorbed, q (e.g., in mol/kg), as a function of

equilibrium concentration in the solution, c (e.g., in mol/L). The graph is for the values of the constants of $K=4$ and $1/n=0.6$.

The Freundlich adsorption isotherm is mathematically expressed as

$$x/m = Kp^{1/n}$$

It is also written as

$$\log x/m = \log K + 1/n \log p$$

or

$$x/m = Kc^{1/n}$$

It is also written as

$$\log x/m = \log K + 1/n \log c$$

Where,

x = mass of adsorbate

m = mass of adsorbent

p = Equilibrium pressure of adsorbate

c = Equilibrium concentration of adsorbate in solution.

K and n are constants for a given adsorbate and adsorbent at a particular temperature.

At high pressure $1/n = 0$, hence extent of adsorption becomes independent of pressure.

It is used in cases where the actual identity of the solute is not known, such as adsorption of colored material from sugar, vegetable oil etc.

Limitation of Freundlich adsorption isotherm

Experimentally it was determined that extent of adsorption varies directly with pressure and then it directly varies with pressure raised to the power $1/n$ until saturation pressure P_s is reached. Beyond that point rate of adsorption saturates even after applying higher pressure [7-9].

Langmuir equation

Irving Langmuir [9-11] was the first to derive a scientifically based adsorption isotherm in 1918 [7].

Often a compound (A) remains relatively more concentrated upon the interface in a heterogeneous system. The result in the concentration of A, in the vicinity of the interface is different from that in the bulk. This phenomenon is called adsorption and it is necessarily related to the surface. [9-11].

The aim of present study was to study the effect of adsorbent on the adsorption of oxalic acid.

Materials & Methods:

Oxalic acid, Charcoal, $KMnO_4$ and H_2SO_4 were purchased from Merck Company, Germany. All chemicals and reagents used in this study were of analytical grade and obtained from Merck Company, Germany.

250 ml of five conical flasks were taken and labeled them 1 to 5. 2 gm of adsorbent (activated charcoal) was weighing accurately and added to each conical flask separately. Specified amount of oxalic acid solution (N/2) and distilled water were pipetted out into each flask as stated to the table 1.

Table 1: oxalic acid solution (N/2) and distilled water were pipetted out into each flask

Flask no.	1	2	3	4	5
Volume of N/2 Oxalic acid (ml)	100	80	60	40	20
Volume of distilled water (ml)	0	20	40	60	20

But here the total volume was made upto 100 ml by adding water after taking oxalic acid which is mentioned in table 1. Then the flask was shaken for 30 min to attain equilibrium. It was then filtered through dry filter paper. 10 ml of filtrate was taken and 150 ml dilute H_2SO_4 (=20ml concentration H_2SO_4 was added. It was warmed to 60-80°C and titrated against standardized (N/10) $KMnO_4$ solution. Then the amount of oxalic acid initially present (C_o), amount of oxalic

acid left per 100 ml of filtrate (C_s), and amount of oxalic acid absorbed per gm of adsorbent were calculated.

$$Y = (C_o - C_s) / \text{Weight of adsorbent}$$

Results & Discussion:

Normality of oxalic acid = 1 (N/2)

Normality of $KMnO_4$ Solution = 1.01 (N/10)

Equivalent weight of oxalic acid = 63

H_2SO_4 = 1:2

100ml of N/2 oxalic acid - $(63 * 100 * 1/2) / 1000 = 3.15$ gm of oxalic acid

Table 2: Initial concentration of oxalic acid in each (Co/100ml)

Flask no.	Volume of stock solution taken (ml)	Initial concentration of oxalic acid (Co-gm/100ml)
1	100	3.15gm/100ml
2	80	2.52 gm/100ml
3	60	1.89gm/100ml
4	40	1.26 gm/100ml
5	20	0.63 gm/100ml

Table 3: Final concentration of oxalic acid after left adsorption

Flask no.	Volume of titrate (ml)	Volume of KMnO4 required	Strength of Oxalic acid (N)	Strength of KMnO4	Final concentration of oxalic acid left [Cs=(N*0.63)gm/100ml]
1	10	40.5	0.409	0.101 (N)	2.55
2		31.8	0.321		2.023
3		23.1	0.233		1.469
4		15.1	0.152		0.95
5		7.1	0.071		0.45

Table 4: Amount of oxalic acid absorbed per gm of adsorbent (Y)

Flask no.	(Co-Cs) gm/100ml	Y=[(Co-Cs)/2] gm/100ml
1	0.6	0.3
2	0.497	0.248
3	0.421	0.2105
4	0.31	0.155
5	0.18	0.09

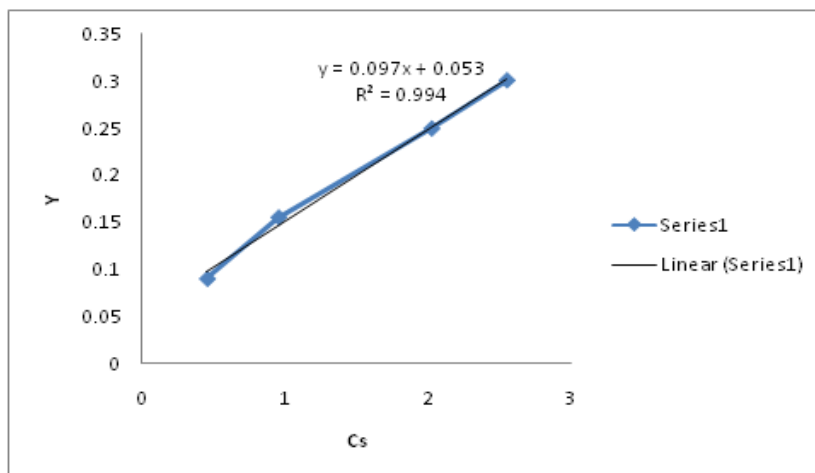


Figure 1: Graphical relationship in between the amount of oxalic acid absorbed per gm of adsorbent (Y) vs final concentration of oxalic acid after left adsorption

Table 4: Amount of oxalic acid absorbed per gm of adsorbent (Y) and final concentration of oxalic acid after left adsorption with their logarithmic values

Flask no.	Y	C _s	logY	logY+2	Log C _s	Log C _s +2
1	0.3	2.55	-0.522	1.477	0.406	2.407
2	0.249	2.02	-0.603	1.396	0.305	2.306
3	0.210	1.469	-0.677	1.322	0.167	2.167
4	0.155	0.95	-0.809	1.19	-0.02	1.978
5	0.09	0.45	-1.045	0.954	-0.34	1.653

From the Freundlich isotherm:

$$Y = KC^{1/n}$$

Or, $\log Y = \log k + 1/n \log C$

From graph,

Slope $1/n = 0.674$

$\log Y = \log K + 0.65 \log C_s$

$\log k = 0.148$

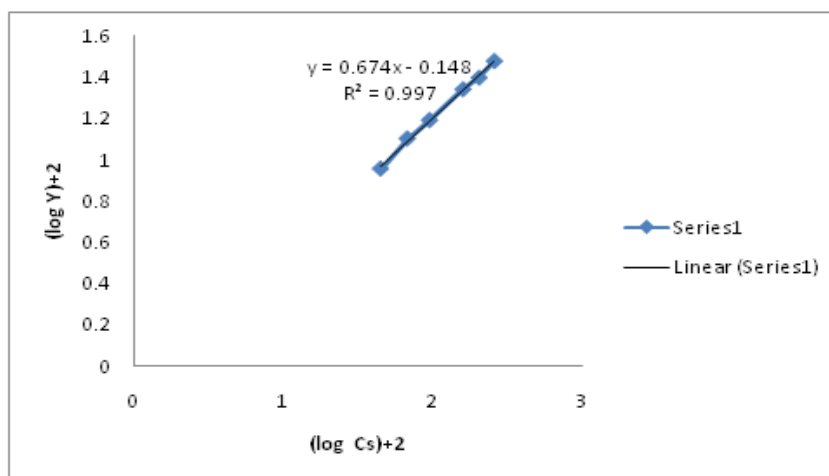


Figure 2: Graphical relationship in between the amount of oxalic acid absorbed per gm of adsorbent (Y) vs final concentration of oxalic acid after left adsorption in logarithmic scale

The surface of the substance of which adsorption occurs is the adsorbent and the substance absorbed is termed as adsorbate. The relation between the amount adsorbed by an adsorbent and the pressure or concentration of adsorbate at a constant temperature is called the adsorption isotherm. The relation between the amount of solute adsorbed from the solution per gm of adsorbent (y) and the equilibrium concentration (C) of the solute is $Y = kc^{1/n}$ or $\log Y = \log k + 1/n \log C$. K and c are empirical constant depending on the system and temperature. From the graphs (figure 1 & 2), it can be concluded that C_s increases exponentially with increases in Y. It can be concluded that C_s increases exponentially with increases in Y and log K value was 0.148 and 1/n was equal to 0.674.

The model applies to gases adsorbed on solid surfaces. It is a semi-empirical isotherm with a kinetic basis and

was derived based on statistical thermodynamics. It is the most common isotherm equation to use due to its simplicity and its ability to fit a variety of adsorption data. It is based on four assumptions [8-11]:

1. All of the adsorption sites are equivalent and each site can only accommodate one molecule.
2. The surface is energetically homogeneous and adsorbed molecules do not interact.
3. There are no phase transitions.
4. At the maximum adsorption, only a monolayer is formed. Adsorption only occurs on localized sites on the surface, not with other adsorbates.

These four assumptions are seldom all true: there are always imperfections on the surface, adsorbed molecules are not necessarily inert, and the mechanism is clearly not the same for the very first molecules to adsorb to a surface as for the last. The fourth condition

is the most troublesome, as frequently more molecules will adsorb to the monolayer; this problem is addressed by the BET isotherm for relatively flat (non-microporous) surfaces. The Langmuir isotherm is nonetheless the first choice for most models of adsorption, and has many applications in surface kinetics (usually called Langmuir–Hinshelwood kinetics) and thermodynamics.

References:

1. "Glossary". The Brownfields and Land Revitalization Technology Support Center. Retrieved 2009-12-21.
2. Ferrari, L.; Kaufmann, J.; Winnefeld, F.; Plank, J. (2010). "Interaction of cement model systems with superplasticizers investigated by atomic force microscopy, zeta potential, and adsorption measurements". *J Colloid Interface Sci.* 347 (1): 15–24.
3. Foo, K.Y.; Hameed, B.H. (2010). "Insights into the modeling of adsorption isotherm systems". *Chemical Engineering Journal.* 156 (1): 2–10. Czepirski, L.; Balys, M. R.; Komorowska-Czepirska, E. (2000). "Some generalization of Langmuir adsorption isotherm". *Internet Journal of Chemistry.* 3(14). ISSN 1099-8292.
4. Wilson, CJ; Clegg, RE; Leavesley, DI; Percy, MJ (2005). "Mediation of Biomaterial-Cell Interactions by Adsorbed Proteins: A Review". *Tissue engineering.* 11 (1): 1–18.
5. Sivaraman B.; Fears K.P.; Latour R.A. (2009). "Investigation of the effects of surface chemistry and solution concentration on the conformation of adsorbed proteins using an improved circular dichroism method". *Langmuir.* 25 (5): 3050–6.
6. Pilatowsky, I.; Romero, R.J.; Isaza, C.A.; Gamboa, S.A.; Sebastian, P.J.; Rivera, W. (2011). "Chapter 5: Sorption Refrigeration Systems". *Cogeneration Fuel Cell-Sorption Air Conditioning Systems.* Green Energy and Technology. Springer. pp. 99,100. ISBN 978-1-84996-027-4. Retrieved 10 May 2011.
7. VanderWiel, D. P.; Pruski, M.; King, T. S. (1999). "A Kinetic Study of the Adsorption and Reaction of Hydrogen on Silica-Supported Ruthenium and Silver-Ruthenium Bimetallic Catalysts during the Hydrogenation of Carbon Monoxide". *Journal of Catalysis.* 188 (1): 186–202.
8. Zupanc, C.; Hornung, A.; Hinrichsen, O.; Muhler, M. (2002). "The Interaction of Hydrogen with Ru/MgO Catalysts". *Journal of Catalysis.* 209 (2): 501–514.
9. Trens, P.; Durand, R.; Coq, B.; Coutanceau, C.; Rousseau, S.; Lamy, C. (2009). "Poisoning of Pt/C catalysts by CO and its consequences over the kinetics of hydrogen chemisorption". *Applied Catalysis B: Environmental.* 92 (3–4): 280–284.
10. Barnes, Brian C.; Siderius, Daniel W.; Gelb, Lev D. (2009). "Structure, Thermodynamics, and Solubility in Tetromino Fluids". *Langmuir.* 25 (12): 6702–16.
11. Jaroniec, M. "Adsorption on heterogeneous surfaces: the exponential equation for the overall adsorption isotherm." *Surface Science* 50.2 (1975): 553-564.